PB82-114646

HERL Biological Exposure Chamber Conceptual Design

Radian Corp.
Durham, NC

Prepared for

Health Effects Research Lab.
Research Triangle Park, NC

Oct 81

U.S. Department of Commerce
National Technical Information Service
NTIS.

PB82-114646

EPA-600/2-81-234
October 1981

HERL BIOLOGICAL EXPOSURE CHAMBER
CONCEPTUAL DESIGN
Technical Note

by

R. M. Parks
Radian Corporation
3024 Pickett Rd.
Durham, North Carolina 27709

Contract No. 68-02-3171

Project Officer

Larry Claxton
Genetic Toxicology Division
Health Effects Research Laboratory
Research Triangle Park, North Carolina 27711

HEALTH EFFECTS RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/2-81-234	ORD Report	PB82 110468

4. TITLE AND SUBTITLE	5. REPORT DATE
HERL BIOLOGICAL EXPOSURE CHAMBER CONCEPTUAL DESIGN Technical Note	October 1981
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) R.M. Parks	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Radian Corporation 3024 Pickett Road Durham, NC 27709	10. PROGRAM ELEMENT NO. C9XA1C
	11. CONTRACT/GRANT NO. 68-02-3171
12. SPONSORING AGENCY NAME AND ADDRESS Genetic Toxicology Division Health Effects Research Laboratory RTP, NC Office of Research and Development U.S. Environmental Protection Agency	13. TYPE OF REPORT AND PERIOD COVERED
	14. SPONSORING AGENCY CODE EPA/600-11

15. SUPPLEMENTARY NOTES
Project Officer: Larry Claxton

16. ABSTRACT

Because of the current interest in biotesting of potentially hazardous air pollutants, the Health Effects Research Laboratory (HERL) of EPA/RTP has contracted Radian to design biological exposure chambers that can be used to expose text organisms to the secondary aerosol effluent of the MARC (Mobile Aerosol Reaction Chamber). The purpose of this technical note is to describe the conceptual design of the biological exposure chambers.

This report describes the chamber design and rationale behind that design. The report also discusses the connecting of the biochambers to the MARC.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	49
	20. SECURITY CLASS (This page)	22. PRICE
	UNCLASSIFIED	

220-1 (9-73)

DISCLAIMER

This report has been reviewed by the Health Effects Research Laboratory, Research Triangle Park, N.C., U.S. Environmental Protection Agency and approved for laboratory publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory participates in the development and revision of air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is primarily responsible for providing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

Radian Corporation is currently under contract to the Environmental Protection Agency (EPA) to design, build, and test a Mobile Aerosol Reaction Chamber (MARC) to generate secondary pollutants from advanced fossil fuel technologies. Because of the current interest in biotesting of potentially hazardous air pollutants, the Health Effects Research Laboratory (HERL) of EPA/RTP has contracted Radian to design biological exposure chambers that can be used to expose test organisms to the secondary aerosol effluent of the MARC. The purpose of this technical note is to describe the conceptual design of the biological exposure chambers.

F. G. Hueter, Ph.D.
Director
Health Effects Research Laboratory

Abstract

Because of the current interest in biotesting of potentially hazardous air pollutants, the Health Effects Research Laboratory (HERL) of EPA/RTP has contracted Radian to design biological exposure chambers that can be used to expose test organisms to the secondary aerosol effluent of the MARC (Mobile Aerosol Reaction Chamber). The purpose of this technical note is to describe the conceptual design of the biological exposure chambers.

The three organisms HERL desires to use for bioassays will be exposed in four different ways. They are 1) Salmonella in petri dishes, 2) Salmonella in erlenmeyer flasks, 3) Drosophila in nylon mesh cages, and 4) Tradescantia cuttings in pots and/or beakers. The physical environment within the four exposure chambers will be controlled to expose the organisms with minimum stress and within published tolerance limits. The four streams that HERL would like to test for biological activity are: 1) the diluted source stream, 2) the filtered MARC exit stream, 3) the unfiltered MARC exit stream, and 4) the clean air supply.

The report describes the chamber design and rationale behind that design. The report also discusses the connecting of the biochambers to the MARC.

CONTENTS

Disclaimer ii

Foreword iii

Abstract iv

Figures vi

Tables vii

1. Introduction 1

2. Size, Shape and Mixing 2

3. Temperature, Lighting and Humidity 10

4. Interfacing the Biochambers to the MARC 12

5. Sampling Systems 18

6. Appendix A 19

7. Appendix B 27

FIGURES

Number		Page
1	Schematic of samples needed by HERL	3
2	Top view of inside of MARC trailer	5
3	Schematic of the reactor system layout in the trailer with proposed biochambers in the rear of the trailer	6
4	Front and side view of HERL biochamber	8
5	Schematic of the reactor system	13
6	Flow diagram for MARC biochamber system	16
A-1	Isometric projection of the field chamber	20
A-2	Front and side view of the field biochamber	21
A-3	Chamber front plate assembly	22
A-4	Field chambers - main casing	23
A-5	Port construction - threaded port and seal	24
A-6	Angle iron frame for biochamber	25
A-7	Laboratory chamber - angle iron frame	26

TABLES

Number		Page
1	Rationale for Biotesting Certain MARC Streams	4
2	Chamber Conditions Necessary for Biological Exposures	11
3	Biochamber Sizes and Inlet Flow Rates	17

SECTION 1

INTRODUCTION

Radian Corporation is currently under contract to the Environmental Protection Agency (EPA) to design, build, and test a Mobile Aerosol Reaction Chamber (MARC) to generate secondary pollutants from advanced fossil fuel technologies. Because of the current interest in biotesting of potentially hazardous air pollutants, the Health Effects Research Laboratory (HERL) of EPA/RTP has contracted Radian to design biological exposure chambers that can be used to expose test organisms to the secondary aerosol effluent of the MARC. The purpose of this technical note is to describe the conceptual design of the biological exposure chambers.

HERL desires to expose several organisms to the MARC effluent, including Salmonella, Tradescantia, and Drosophila. Radian has designed the HERL Chamber in such a way that the organisms can be suitably exposed and the MARC is unaffected by the chamber operation. The process of designing the chamber required consideration of the following:

- Insuring that the conditions within the chamber are conducive to the growth and survival of the organisms, and consistent with established experimental protocols,
- Matching the HERL Chambers to the MARC so that the aerosols are introduced into the chamber with minimum impact on the MARC, and
- Designing a sampling system so that certain specimens in the chambers can be treated in such a way that their exposure to the chamber environment is stopped while the remainder of the specimens are continuously exposed.

Sections 2 and 3 of this technical note are concerned with the conditions within the chambers. Section 4 is concerned with connecting the biochambers to the MARC, and Section 5 is concerned with sampling the organisms in the chambers.

SECTION 2

SIZE, SHAPE AND MIXING

The size and shape of the HERL biological exposure chamber will be determined mainly by the constraints of the trailer presently housing the MARC. While the chamber must be designed to perform the functions HERL desires, the exposure chamber must fit into the available space in the trailer and not perturb the operation of the MARC. This section will discuss how the space requirements of HERL's chamber can be worked into the present MARC trailer, and the effects the biochamber shape will have on its mixing characteristics.

There are four (4) different streams that HERL would like to test for biological activity. These streams are shown schematically in Figure 1 and the rationale for testing these streams is given in Table 1. In order to successfully expose biological organisms to all these streams, four separate exposure chambers must be built.

The amount of space available for the HERL chambers in the MARC trailer is limited, and will have to be either in the front or the rear of the MARC reactor. Figure 2 is a top view schematic layout of the inside of the trailer indicating the available space for the biochambers. Since it is desirable to keep all the biochambers together, they will be located in the rear of the trailer where there is the most room.

The area above the wheel well opposite the ozone generator is large enough to accommodate four biochambers, 3 ft wide, 1.5 ft high and 1.5 ft deep. Figure 3 is a side view schematic illustration of the MARC trailer showing the proposed location of the biochambers. In order to keep all the biochambers in one location, Radian will stack the chambers. this stacked configuration will allow the most efficient utilization of the available space.

Radian recommends a rectangular configuration for the chamber shape. While this shape will not be the best for mixing the contents of the chambers, it will make the best use of the available trailer space. A cylindrical vessel that would fit in the same space and give better mixing performance would cut the number of Petri dish samples by half and would not offer any advantages over the rectangular shape. Also, there will be shelves and containers in the chambers which will have more of an effect on the mixing characteristics than the vessel shape. Although Radian does not anticipate any major mixing problems, thoroughly testing and documenting of the mixing characteristics of each chamber is recommended before biotesting is initiated.

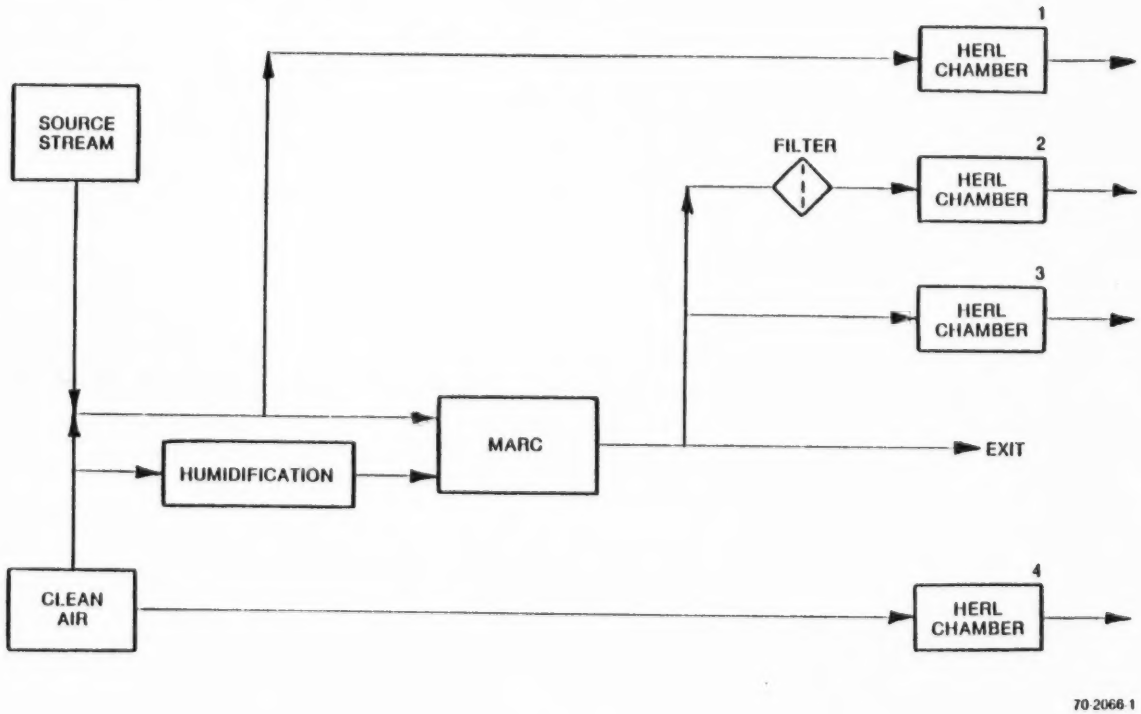


Figure 1. Schematic of samples needed by HERL.

TABLE 1. RATIONALE FOR BIOTESTING CERTAIN MARC STREAMS

	Stream Description	Sampling Rationale
1)	Diluted Source Stream (MARC Feed)	To determine mutagenic activity of primary emissions.
2)	Filtered MARC Exit Stream	To test the gas phase only.
3)	Unfiltered MARC Exit Stream	To test aerosols and gas phase.
4)	Clean Air Supply	To determine the background level of genetic reversions for control.

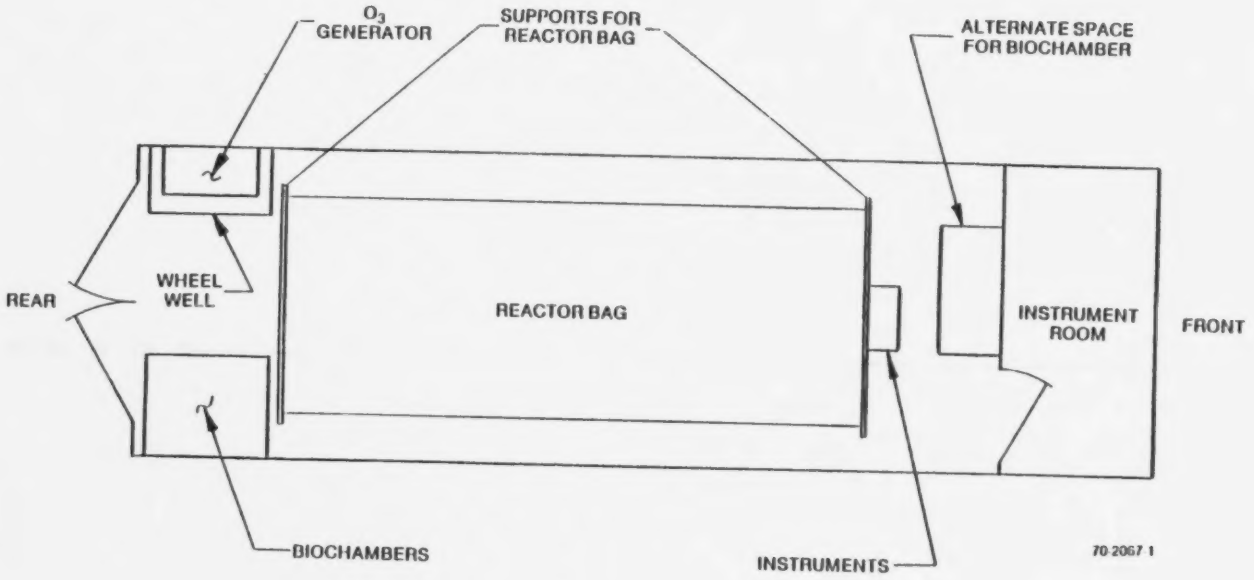


Figure 2. Top view of inside of MARC trailer.

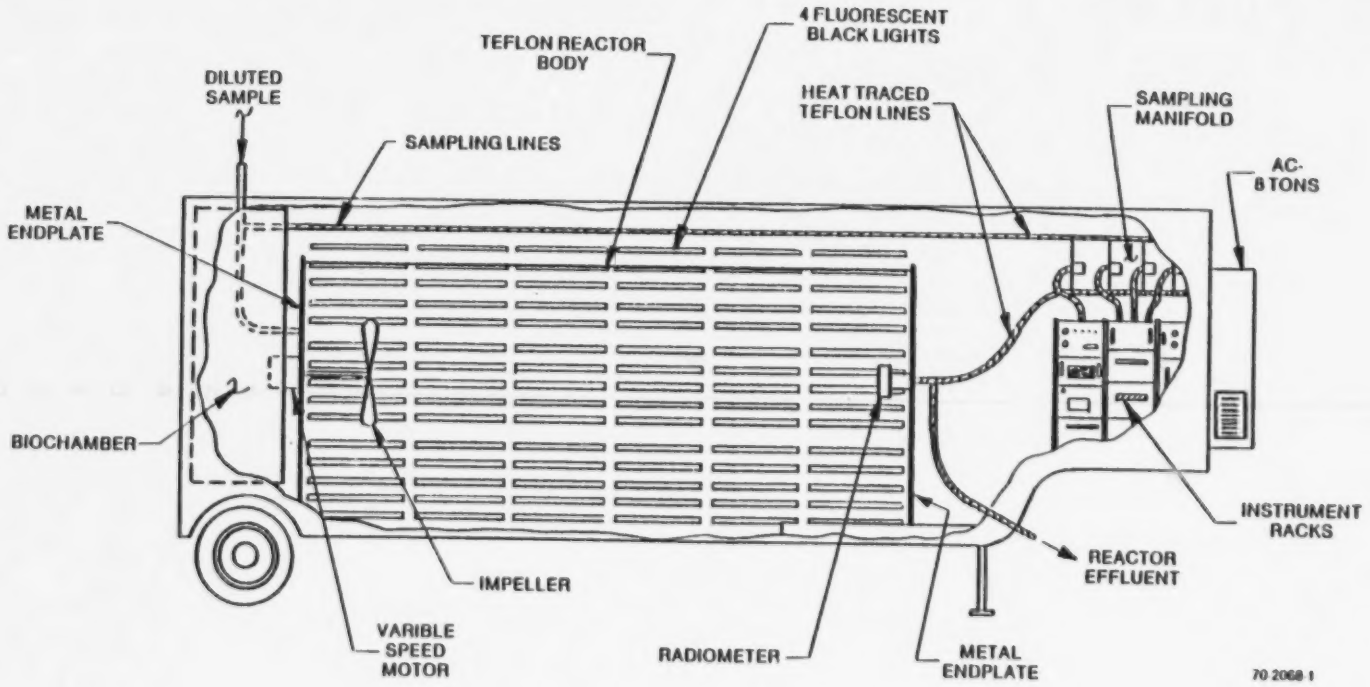


Figure 3. Schematic of the reactor system layout in the trailer with the proposed biochambers in the rear of the trailer.

Figure 4 shows the recommended chamber shape, and the size of each unit, designed to conform to the available space. (Detailed construction drawings are shown in Appendix A.) All the chambers are the same size, having a working volume of 6.75 cubic feet. The contents of the chambers will be continually stirred with an impeller located in one end of each chamber. The locations of these impellers are shown in Figure 4. Residence Time Distribution (RTD) tests will be conducted on the finished chambers to assess the extent of the non-ideal mixing in the vessels. If the mixing characteristics of the chambers are found through these Residence Time Distribution, to be inadequate, a second impeller will be placed in the chambers and the RTDs run again.

The three organisms HERL desires to use for bioassays will be exposed in four different ways. They are:

Salmonella	-	Petri dishes Erlenmeyer flasks
Drosophila	-	Nylon mesh cages
Tradescantia	-	Pots or beakers

Since the chambers will be used to expose three different types of organisms, the internal configuration of the chambers will vary for each organism.

For the Salmonella, two methods of exposure are desired. To expose the petri dish samples, a shelf will be inserted in the chambers and the petri dishes placed on the shelf and bottom of the chamber, each area accommodating approximately 35 dishes. There will be two openings in each of the chambers, as shown in Figure 4, to make access to each of the shelves easier. The mixing impellers will be located between the shelves and adequate holes cut in the shelves to facilitate homogeneous circulation of the fluid in the chambers. The input port for the aerosols will be in the upper part of the vessels on one side, and the exit port will be located on the opposite side in the lower part of the vessel. This design should allow for a uniform exposure of the Salmonella since the chamber itself is partially blocked with shelves and dishes.

When Salmonella are exposed in Erlenmeyer flasks, appropriate fittings can be used to introduce the aerosols directly from the MARC to the liquid medium in the flasks. Small rotary shakers will be used to mix the contents of the flasks. These shakers can be placed directly in the biochambers if temperature control is a problem, or they can be left out of the chambers if temperature control is not a problem.

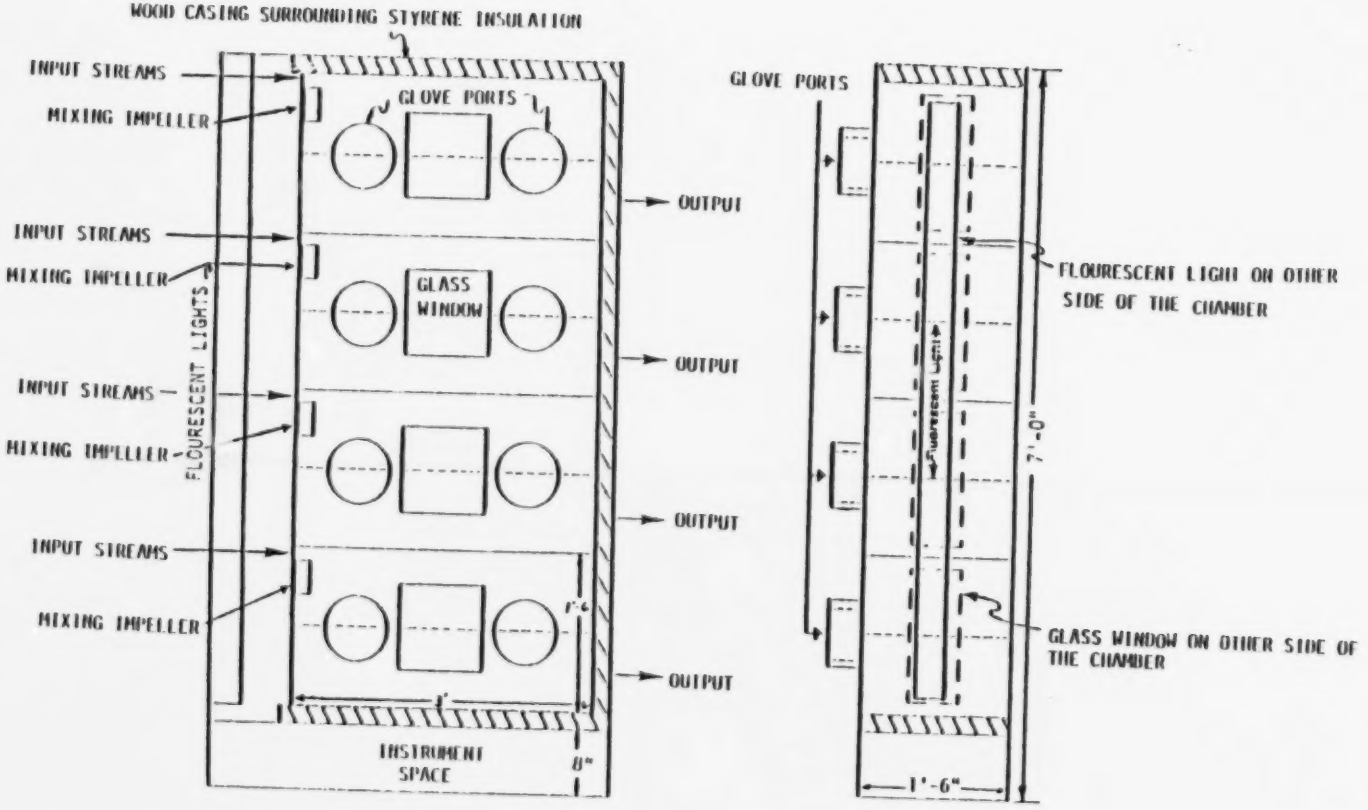


Figure 4. Front and side view of HERL biochambers.

To expose the Drosophila to the MARC effluent, the top shelf of the biochambers can be removed to allow stacking of cages containing the organism in the chambers. The number of cages that can be located in the chambers for a given experiment can be predetermined by HERL when they size cages. This allows HERL a greater degree of flexibility in experimental design.

Cuttings of Tradescantia can be exposed in a chamber of configuration similar to the ones used for Drosophila. Cuttings can be placed in a small pot or beaker and the beakers inserted in the chambers to obtain multiple exposures. This method of exposure allows for large amounts of data collection which would aid HERL in obtaining statistical valid results.

For both the Drosophila and Tradescantia exposures, a feed stream for each biochamber will be introduced in the upper part of the vessel and the output will be in the lower part of the chamber. These requirements can be readily met with the chambers as described above for Salmonella.

SECTION 3

TEMPERATURE, LIGHTING AND HUMIDITY

The physical environment within each chamber will be controlled to expose the organisms with minimum stress and within published tolerance limits. Table 2 lists the conditions that will be maintained within each chamber for satisfactory performance.

TEMPERATURE

The temperature that should be maintained in the biochambers while exposing the Drosophila and Tradescantia can be the ambient trailer temperature with no damage to the organisms. For runs utilizing these organisms, as well as experiments exposing Salmonella at ambient conditions, the heating or cooling of the chambers will be no problem. The trailer housing the MARC is sufficiently conditioned to hold the MARC as well as the biochambers at the desired temperatures. However, when running Salmonella at the higher temperatures, 37 ± 0.5°C, auxiliary heating equipment will be used to elevate the chamber temperature. Also, adequate insulation will be provided around the chambers to reduce heat loss.

HUMIDITY

The relative humidity in the biochambers needs to be kept at 60 to 80 percent for all the organisms. When the MARC is operated at the high relative humidity condition, there will be little problem maintaining the necessary moisture in the biochambers when they are operated at ambient temperatures. However, for the high temperature Salmonella runs, as well as the MARC runs at low humidity levels, moisture will have to be added to the biochambers to raise the relative humidity to the desired level.

LIGHTING

Both Drosophila and Salmonella can be exposed to the secondary aerosols in the dark. However, Tradescantia should be exposed in a lighted environment for a maximum response to the aerosols. The amount of light will not be critical, but should be photosynthetically active radiation. By exposing the Tradescantia system under lighted conditions, the stamens of the organism remain open and diffusion of the aerosols into them will be maximized.

TABLE 2. CHAMBER CONDITIONS NECESSARY FOR BIOLOGICAL EXPOSURES

Organism	Temperature Optimum(min-max)	Humidity	Lighting Needs	Comments
Drosophila	25°C (17-29°C)	60-70%	Can be exposed in the dark	-too dry and no egg laying -too hot and males will be sterile
Tradescantia	Ambient (20°-25°C)	Ambient	Should be exposed under lighted conditions	-less sensitive to humidity and temperature changes than Salmonella or Drosophila
Salmonella	37°C ± 0.5	60-80%	Must be exposed in the dark	-sterile conditions needed

SECTION 4

INTERFACING THE BIOCHAMBERS TO THE MARC

Since the biochambers are considered auxiliary testing devices for the aerosols produced in the MARC, they must be attached to the MARC in such a way that they do not disturb the operation of the aerosol reaction chamber. Although there are to be four compartments in the biochamber module, only two of these will directly utilize the MARC effluent.

FLOW PATTERNS FOR CHAMBER INTERFACE

Connecting the HERL biochambers to the MARC will be done in such a way as to supply the biochambers with the desired aerosol effluent while not causing any adverse effects on the MARC. Figure 5 is a schematic flow diagram of the MARC. Figure 1 in Section 2 presented a schematic of the four streams that need to be sampled in order to satisfy the needs of the HERL biological experiments. Two of these MARC streams can be sampled with no perturbation to the system.

1) The clean air supply

2) The diluted source stream (the MARC feed stream)

Since the clean air system is capable of delivering up to ten cubic feet per minute (10 cfm) and the MARC will only require 1-3 cfm, there will be enough excess clean air to feed the clean air section of the biochamber. The flow rate of this stream to the biochamber will be in the range of 0.25 to 0.5 acfm. Since the chamber volume is 6.75 ft^3 the residence time (τ) in the clean air chamber will be 13.5 to 27 minutes. Provisions will be made to humidify this chamber since the clean air is dry (a 0% relatively humidity). The feed stream to this chamber will be tapped from the clean air feed just downstream of the clean air generator. This will cause the clean air chamber to operate at a positive pressure. The exit from this chamber can be routed to the atmosphere with no further treatment.

The diluted source stream is the second stream which should be in plentiful supply and should pose no sampling problems. This stream will be sampled after all dilutions have occurred and will be transported to the appropriate biochamber by a line large enough to keep the pressure drop across the system to a minimum. The stream will be tapped off the MARC feed stream between the inlet manifold and the inlet sampling pump. This arrangement will mean that the biochamber is operating at a pressure

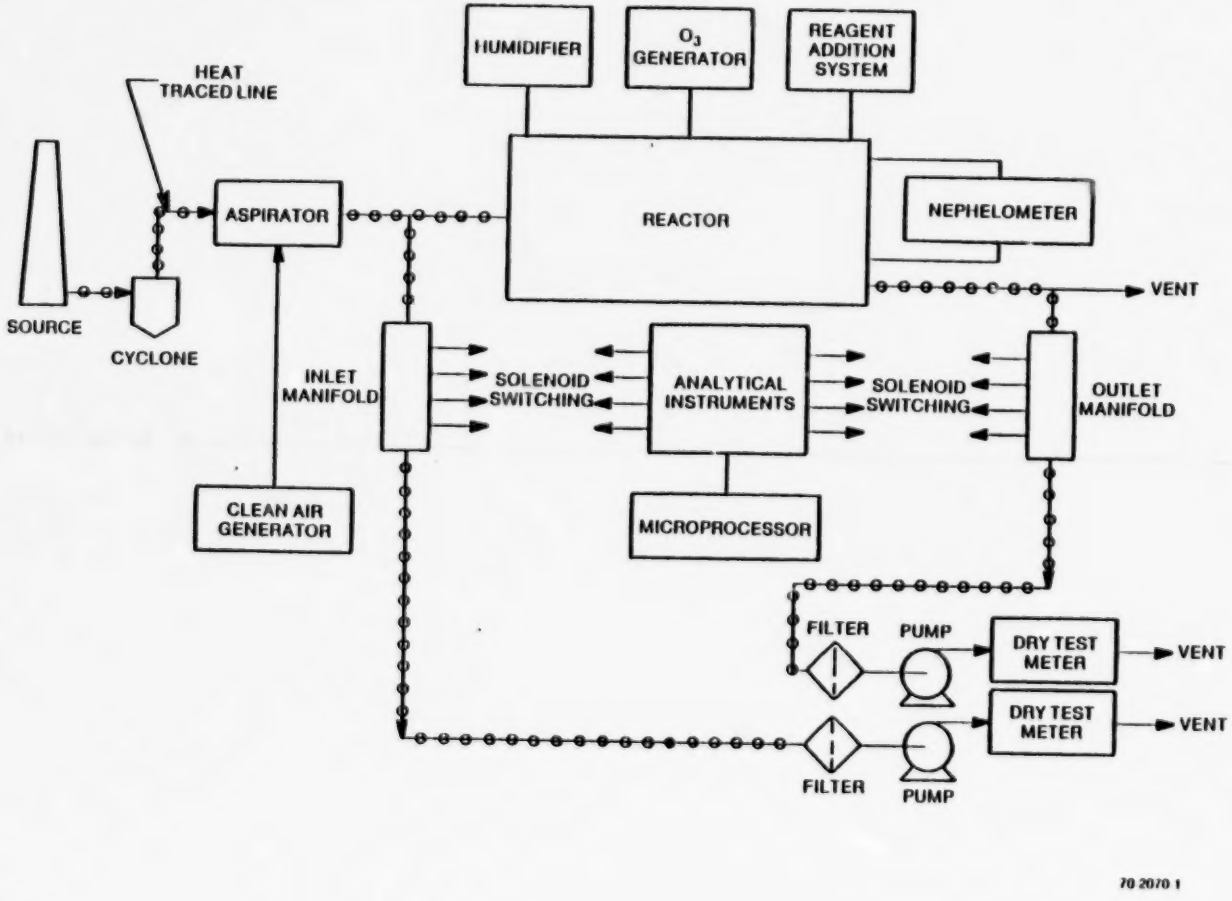


Figure 5. Schematic of the reactor system.

slightly below atmospheric. The flow rate of this stream will be between 0.25 and 0.5 acfm to give an average residence time (τ) of 13.5 to 27 minutes for the 6.75 ft^3 chamber. Also, since the stream will be sampled before it is humidified, provisions for humidifying this chamber will be necessary to provide the exposure conditions discussed in Section 3. The exit stream from this reactor can be routed to the atmosphere.

Two samples remain that HERL would like to test for biological activity.

1) A filtered MARC exit stream

2) An unfiltered MARC exit stream

Both of these streams will come directly from the MARC.

Of the two samples, the filtered effluent sample can be most easily obtained. Figure 5 shows the output stream leaving the MARC and being split into two streams. One of these streams goes to a sampling mainfold where periodic samples are taken for chemical characterization. The excess from this manifold is pumped through a final filter and exhausted through a dry test meter to the atmosphere. Since the flow rate of this line will be on the order of 1 cfm, the biochamber can be inserted between the final outlet filter and the outlet sampling pump. The feed to the biochamber will be the stream coming from the outlet filter and the exit stream from the biochamber would be returned to the outlet pump. The pump exhaust could be dumped to the atmosphere as originally planned or filtered again for sample collection. Since the feed to the biochambers is taken upstream of the pump intake, the biochamber will operate at a negative pressure. The pressure drop through the biochamber is expected to be small and there should be little disturbance to the MARC system.

The final sample HERL would like to bioassay is the unfiltered MARC effluent. Since this sample will contain aerosols, it will be best not to transport the sample any great distance. A separate output port will be placed in the MARC at the rear of the trailer in the area where the biochambers are located. While this separate output line from the MARC will represent an ideal feed for the biochamber, several things have to be considered before a successful interface can be achieved. At present, the total flow rate of material through the MARC has not been determined and since a mass balance has to be satisfied around the MARC (Input to MARC = Output from MARC) only the extra aerosol beyond that needed for chemical characterization will be available for the biochamber feed. If baseline chemical characterization tests show that enough aerosols can be collected with a high throughput of feed materials, then there will be enough aerosols remaining for the biochamber feed. The final decision on this matter will have to await the completion of the chemical characterization of the MARC output.

As in all the other cases, the line taking the effluent sample to the biochamber will be sized to prevent significant pressure drop across the system. Depending on the final outcome of the chemical test, the flow rate to this chamber could be 0..25 to 0.5 acfm, giving a residence time (τ) of 13.5 to 27 minutes. Also, water will have to be added to this chamber to bring the relative humidity up to the desired level for the high temperature runs.

The biochamber will need to have a filter and pump downstream of the exit and will operate at a slight negative pressure. There should be only a slight pressure drop associated with passing the effluent through the biochamber and connecting lines and should cause no problems in the MARC operation. At present, a restricting orifice is used to adjust the back pressure in the chamber by controlling the flow in the vent line. The size of this orifice will have to be adjusted to allow the proper pressures and flows in the MARC allowing the two reaction vessels to operate at almost the same pressure.

Figure 6 is a schematic that shows the interface of the biochambers to the MARC. All the above flow pattern discussions are included on this figure. Table 3 lists all the chamber sizes for each biochamber along with its proposed input flow rate and residence time. Provisions will have to be made to humidify all the chambers. Also, check valves will be placed in the feed lines to all the biochambers in case there is a loss of pressure in any part of the system. The check valves would keep gas from the biochamber from contaminating any of the rest of the MARC system.

Since three of the chambers are operating at negative pressures, the output of the pumps will vent to the atmosphere and are not anticipated to cause any more problem than venting the associated MARC process stream itself.

A separate flow system will be provided to flush all the chamber with clean, sterile air before the start of each experiment. This stream will be provided by filtering air from the existing MARC compressor, or a separate compressor may be used. Filters will have to be installed in line to provide the required quality of air. This arrangement will insure that the experiments are started with sterile air in the chambers.

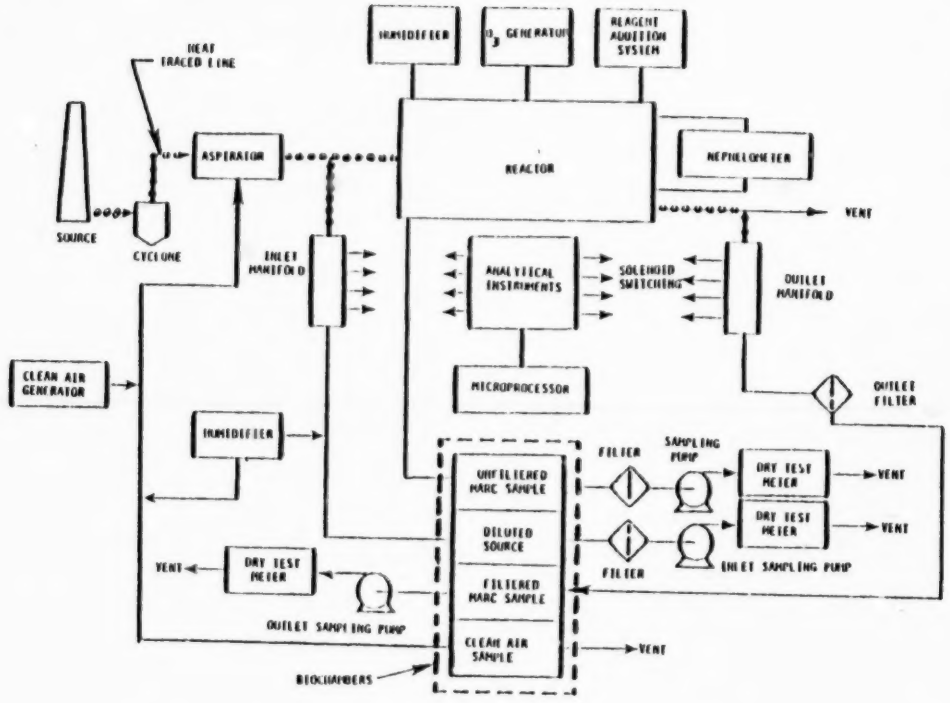


Figure 6. Flow diagram for MARC (biochamber system).

TABLE 3. BIOCHAMBER SIZES AND INLET FLOW RATES

Chamber Description	Volume, ft^3	Inlet Flow Rate, cfm	Residence Time (τ) min
1) Clean Air Supply	6.75	0.25 - 0.5	13.5 - 27
2) Diluted Source Stream	6.75	0.25 - 0.5	13.5 - 27
3) Filtered MARC Exit Stream	6.75	0.25 - 0.5[a]	13.5 - 27
4) Unfiltered MARC Exit Stream	6.75	0.25 - 0.5[a]	13.5 - 27

[a]Will have to be set at a later date, these numbers only represent estimates.

SECTION 5

SAMPLING SYSTEMS

To determine the effect of doseage, it is necessary that samples be periodically isolated from the exposure stream. This type of operating procedure will enable HERL personnel to develop dose-responses information on the organisms exposed to the aerosols. The doseage variable can in this way be expressed in units of time. To do this, the exposure chambers have to be filled with the appropriate number of test organisms, and certain ones isolated at given intervals. For Salmonella exposed in petri dishes, it will be possible to cover the petri dish at the appropriate time and limit exposure. This will be the easiest and least disturbing method of sample control for the chamber. For Tradescantia and Drosophila, the organisms also can be isolated from the aerosol environment of the biochambers. The provisions for handling the samples in this way will have to be designed into the chamber sampling system.

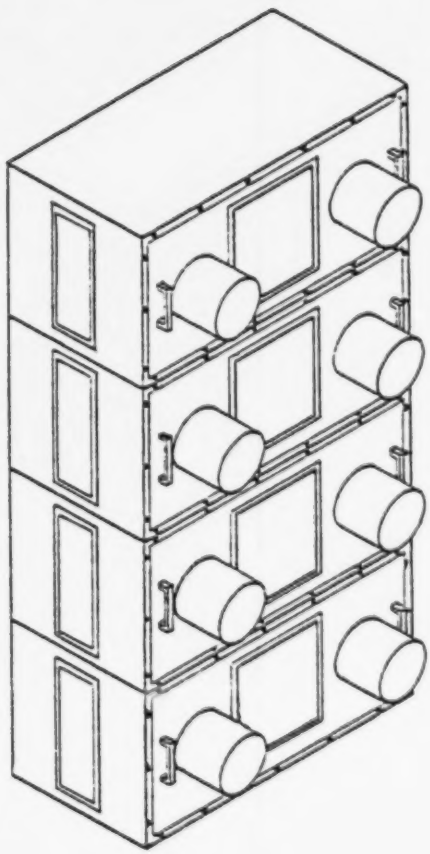
Several techniques can be employed to isolate the organisms, Tradescantia and Drosophila, from the reactive aerosols. The simplest system is to insert the organisms into an isolation vessel contained inside the biochambers. The isolation vessel can be purged of the aerosal reactants and the biological exposures effectively quenched. The biochambers have been designed to accomodate this type of isolation procedure. The glove/glove box design of the front panel of the biochambers will allow easy access into all areas of the chambers and facilitate the isolation of selected samples. The isolation vessel will be a flexible-walled container that can be flushed with clean air from the clean air system. Appropriate converters will be used to pass the clean air from the generating system outside the chambers to the isolation vessel inside the biochambers. When the entire experiment is completed, the front panel of the chambers can be removed and the specimens recovered.

Since there is a potential to get uneven mixing in the chambers due to shelves and sample containers, experiments will have to be statistically designed to ensure that the correct samples are isolated. For example, petri dishes containing Salmonella located in one section of the chamber might obtain a higher dose of aerosols than some located in another area. To insure valid results for the experiments, a statistical analysis of the isolation of the plates will have to be done so that the plates that are removed represent an unbiased sample. Statistical sampling plans will need to be developed when the test plans for the biochambers are written.

While each of the three types of organisms will require their own type of sampling protocol, the glove arrangement will offer the maximum protection and flexibility to all the samples.

APPENDIX A

Detailed Design Drawings



SCALE- 3/4=1'-0"

Figure A-1. Isometric projection of the field chamber.

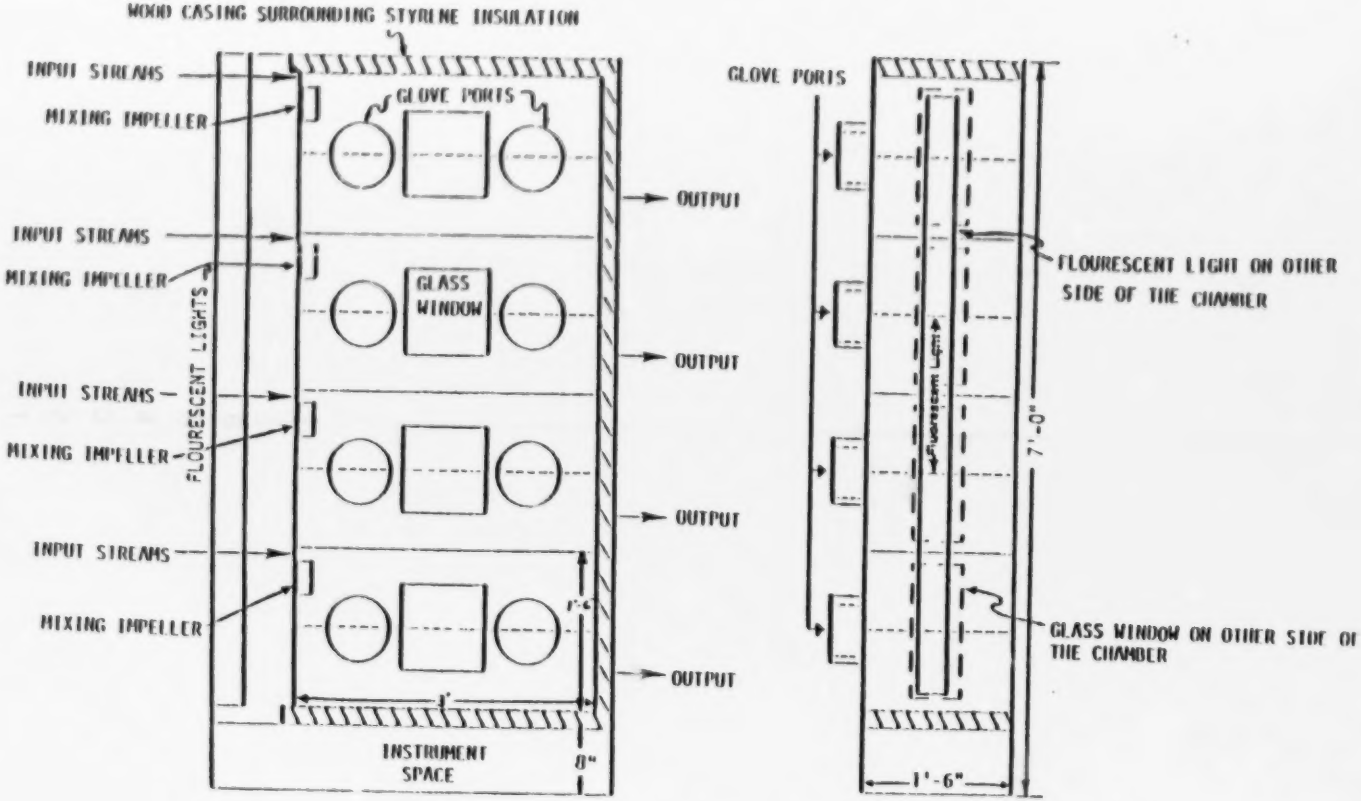


Figure A-2. Front and side view of the field biochamber.

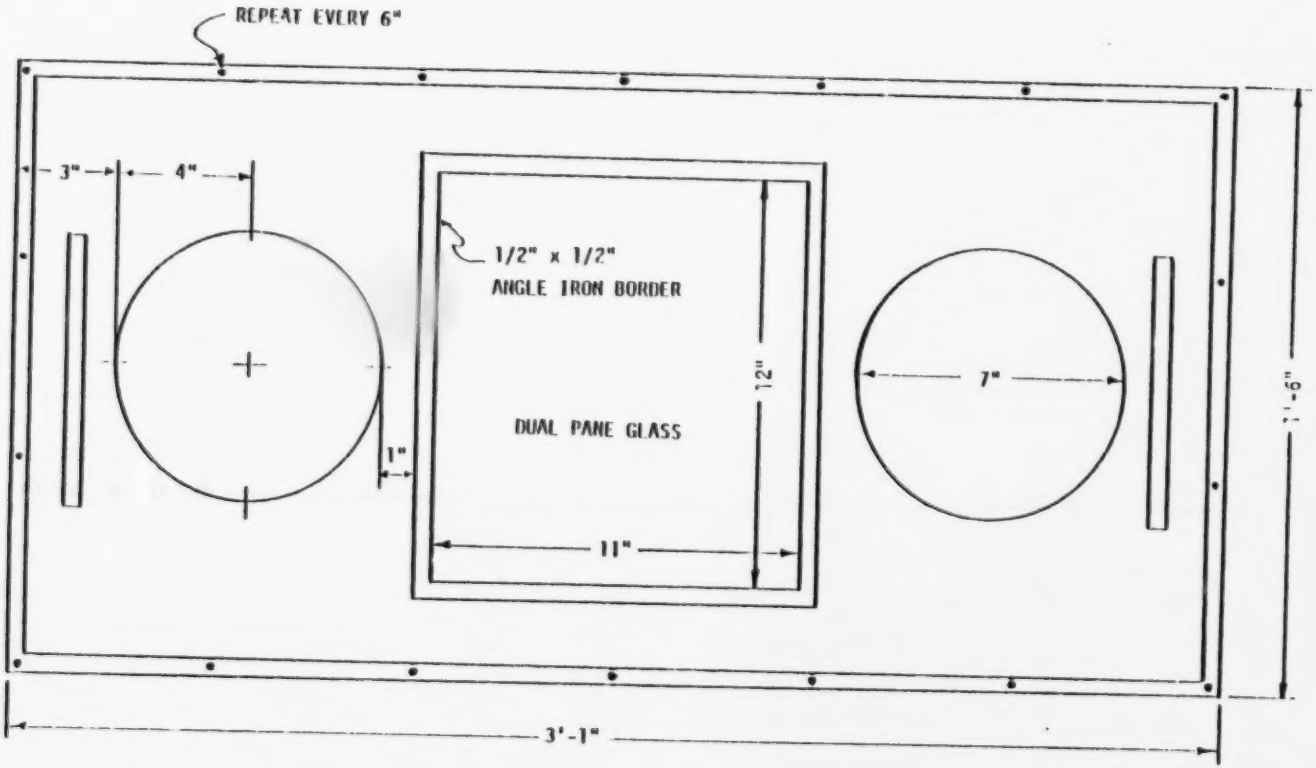


Figure A-3. Chamber front plate assembly.

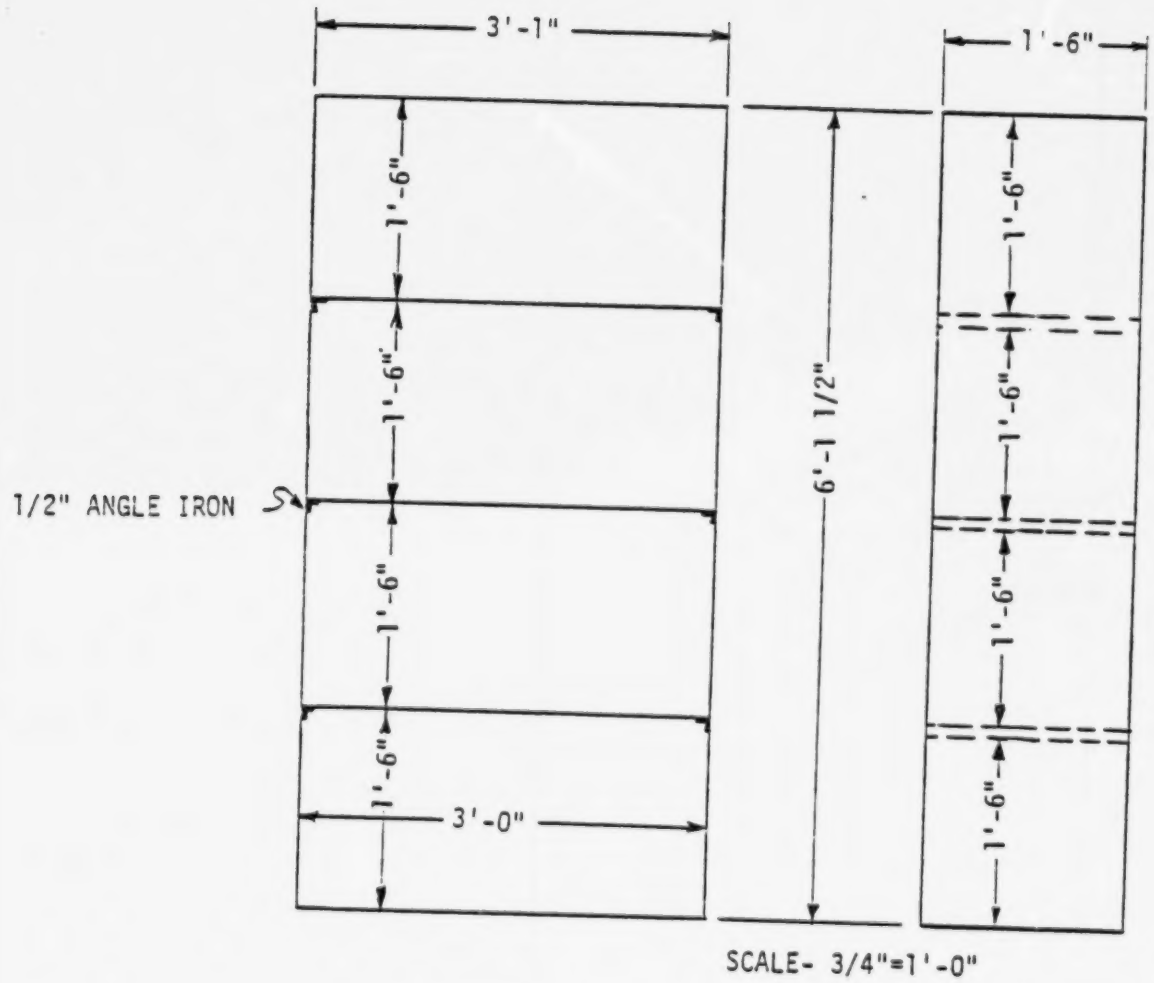


Figure A-4. Field chambers - main casing.

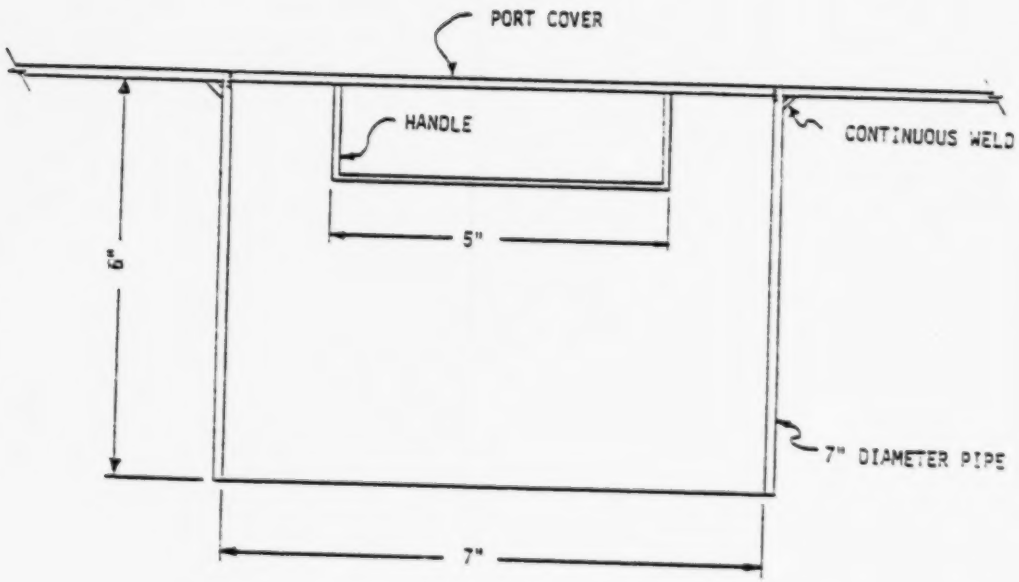
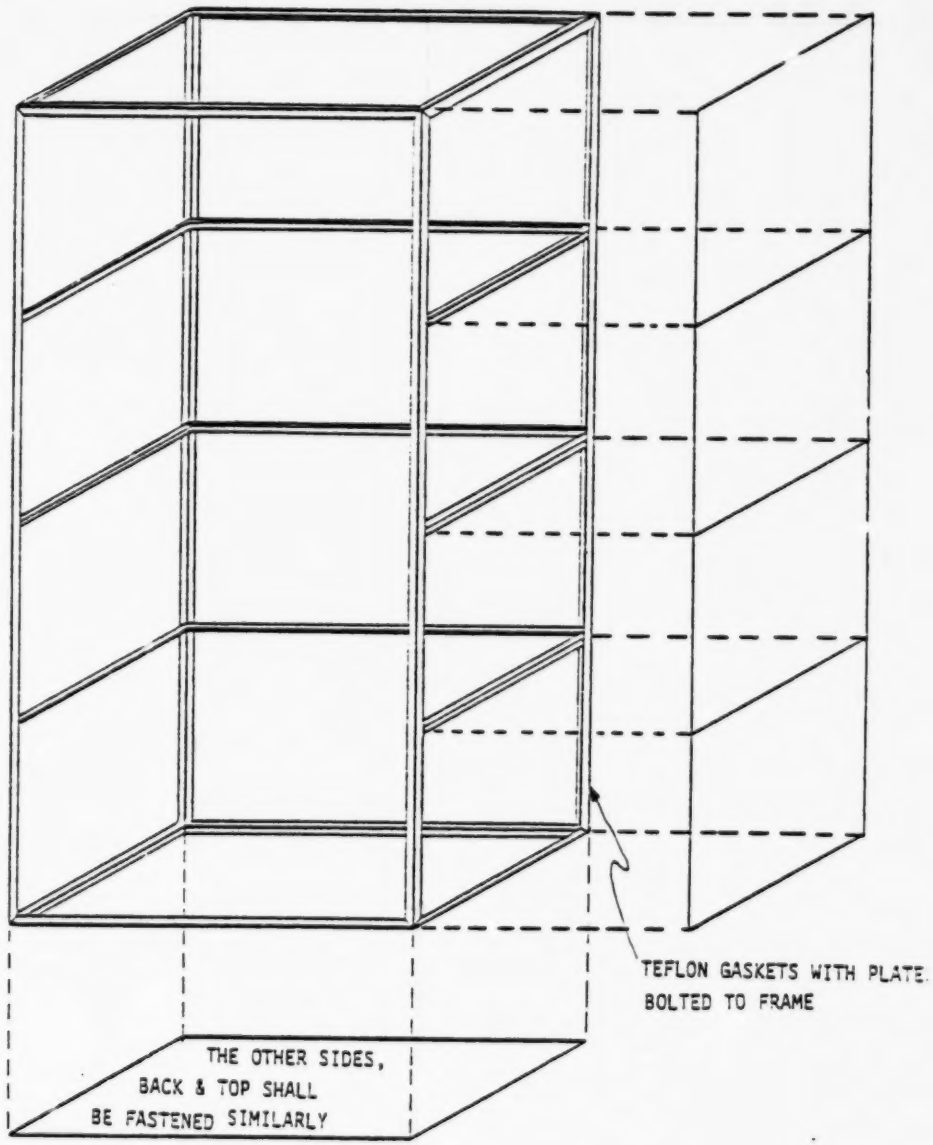


Figure A-5. Port construction - threaded port and seal.



CONSTRUCTION: 1/2"x1/2"x1/8" ANGLE IRON
16 GAUGE STEEL SHEET SIDES

SCALE- 1" = 1'-0"

NOTES: ALL STEEL PLATES WILL BE FASTENED TO FRAME WITH BOLTS & SEALED WITH TEFLON GASKETS

Figure A-6. Angle iron frame for biochamber.

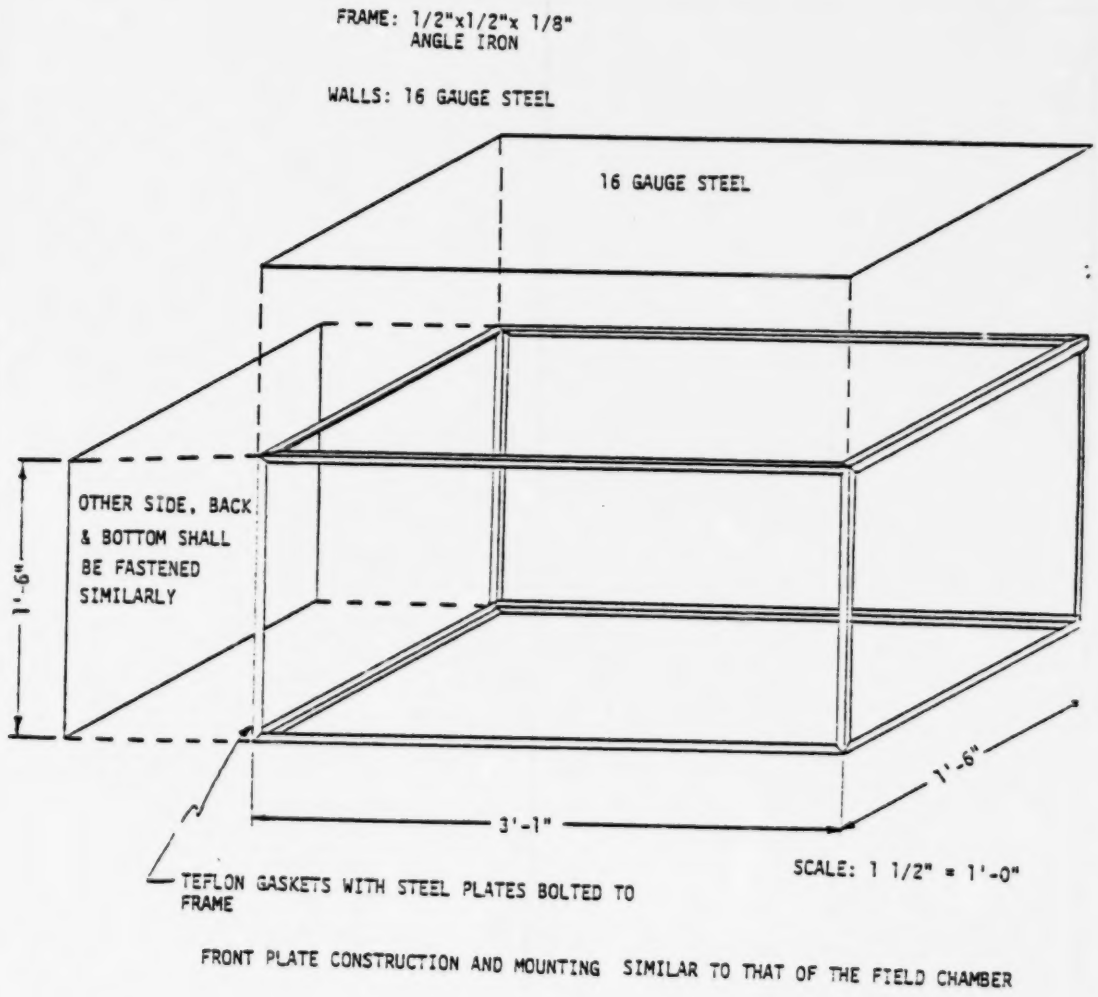


Figure A-7. Laboratory chamber - angle iron frame

APPENDIX B

Biochamber Parts List

Appendix B is a listing of parts needed to construct one field biological exposure chamber and one laboratory biological exposure chamber. Some parts needed for the connection of the field chamber to the MARC are not listed, but will be supplied during construction.

A & I PLASTICS
2316 Rutland (512) 837-2710
Austin, Texas

Item	Quantity	
1	10	Teflon gasket material "Zip Joint" 1/4" 25' roll

AMERICAN SCIENTIFIC PRODUCTS
210 Great Southwest Parkway (214) 647-2000
Grand Prairie, Texas 75050 (800) 492-4820 Tx. watts

Item	Quantity	Stock No.	
1	5	T2850-1	Controller, Temperature controller, model 63 RC, YSI
2	5	Probe T2900	Temperature probe for YSI controller
3	5	E2101-2	Auto transformer
4	1	L6080	Mineralight

ARTHUR VALVE AND FITTING

Item	Quantity	Stock No.	
1	5	SS-1610-6	Union 1" tube o.d. [NY]
2	2	SS-600-6	Union 3/8" tube o.d. [NY]
3	1	SS-1210-6-8	Reducing union (1/2" to 3/4") (1-m)
4	2	SS-810-R-16	Reducer (1/2" to 3/8") (2-fm)
5	1	SS-1010-1-12	Male Connector 5/8" swage to 3/4" pipe (1-m)
6	5	SS-600-9	Union elbows 3/8" to 3/8" [NY] (1/chamber field & backup)
7	5	SS-200-61	Bulkhead union (1/8") (1/chamber)
8	12	SS-400-1-2-OR	O-Seal male connector pipe thread (2/chamber)
9	12	BSS-600-1-2	Male connectors fractional tube to NPT thread (2/pump)
10	2 arbors	SS-600 sets-10	3/8" ferruled [NY]
11	1	SS-600-3	Union tee 3/8" [NY] (1-c)
12	1	SS-16-T	1" pipe union tee
13	1	SS-44X58	3-way ball valve
14	8	B-1R56	Regulating valves
15	10	NY-600-6	3/8" Union (gas drying system)

CURTIN MATHESON SCIENTIFIC
4220 Jefferson Avenue
Houston, Texas 77023 (713) 923-1661

Item	Quantity	Stock No.	
1	1	322-077	Slack tube manometer
2	25 lbs.	117-236	Silica Gel, Indicating

DOVE PLASTICS INSULATIONS, INC.
209 Pleasant Valley Road
Austin, Texas (512) 385-6764

Item	Quantity	Stock No.	
1			1 " thick styrene insulation:
	3		4' x 8' sheets

FISHER SCIENTIFIC
Houston, Texas (713) 495-6060

Item	Quantity	Stock No.	
1	1	91-431	8-outlet console (power supplies to heaters' autotransformers)
2	1		4-outlet console (power to fans)
3	5	11-463-15	Quartz heater (chamber heaters)
4	5	11-661-10	Desk hydrometers
5	10	92-066	Needle valve with 2-hose
6	6 pr.	92-050B	Two-part gloves with sleeve
7	10	11-391-101	Clamping ring

GRAYBAR ELECTRIC CO. INC.
2434 N. Larmar
Austin, Texas (512) 454-0301

Item	Quantity	Stock No.	
1	1		6' fluorescent fixture with ballast
2	1		6' fluorescent tube 120w
3	3		Incandescent fixtures 20w

NEWARK ELECTRONICS
4438 Centerview Drive
San Antonio, Texas 78228 (512) 736-1738

Item	Quantity	Stock No.	
1	10	57F2603	2.5 watt induction type fans 21-42 VAC Type 900 fan
2	10	57F2606	5.6 mfa capacitors. Type 1011 capacitor

RELIANCE STEEL
P.O. Box 18345
San Antonio, Texas 78128

Item	Quantity	Stock No.	
1	15 sheets		12 ga. steel 18" x 36"
2	5 sheets		12 ga. steel 18" x 18"
3	5 sheets		1/4" steel plate 18" x 18"
4	15		1" x 1" x 1/8" angle iron 20 ft units

STRIPLING BLAKE LUMBER CO., INC.
3400 Steele
Austin, Texas (512) 454-0401

Item	Quantity	Stock No.	
1	3		8' x 4' x 1/2" type AB plywood sheets
2	2 lbs		finishing nails
3	3		spray paint for metal exterior surfaces

VACUUM TECHNOLOGY
9411 Neils Thompson
Austin, Texas (512) 837-5040

Item	Quantity	Stock No.	
1	4		Dry gas meters
2	5		Thomas pumps model 107CA18TFE
3	100 ft		3/8 Tygon tubing

WESTBROOK METALS
646 Cenion
Austin, Texas 78752 453-6044

Item	Quantity	Stock No.	
1	6'		3/8" stainless steel tubing
2	6'		1" stainless steel tubing
3	5'		3' o.d. thin wall steel pipe
4	4		20 ft. lengths 1" x 1/8" steel strip (flat)